THE AQUATIC PLANT COMMUNITY FOR UPPER CAMELOT LAKE ADAMS COUNTY 2006

I. INTRODUCTION

An updated aquatic macrophytes (plants) field study of Upper Camelot Lake was conducted during August 2006 by a staff member the Adams County Land and Water Conservatism Department and a staff member of the Tri-Lakes Management District. The first quantitative vegetation study was performed by Wisconsin Department of Natural Resources staff in 2000.

Information about the diversity, density and distribution of aquatic plants is an essential component in understanding the lake ecosystem due to the integral ecological role of aquatic vegetation in the lake and the ability of vegetation to impact water quality (Dennison et al, 1993). This study will provide information useful for effective management of Upper Camelot Lake, including fish habitat improvement, protection of sensitive areas, aquatic plant management, and water resource regulation. This data will be compared to the past and future studies and offer insight into changes in the lake.

Ecological Role: Lake plant life is the beginning of the lake's food chain, the foundation for all other lake life. Aquatic plants and algae provide food and oxygen for fish and wildlife, as well as cover and food for the invertebrates that many aquatic organisms depend on. Plants provide habitat and protective cover for aquatic animals. They also improve water quality, protect shorelines and lake bottoms, add to the aesthetic quality of the lake, and impact recreation.

Characterization of Water Quality: Aquatic plants can serve as indicators of water quality because of their sensitivity to water quality parameters such as clarity and nutrient levels (Dennison et al, 1993).

Testing has shown that Upper Camelot Lake has very hard water. Lake water pH has ranged from 6.48 to 8.3. Hard water lakes tend to produce more fish and aquatic plants than soft water lakes.

Background and History: Upper Camelot Lake is located in the Town of Rome, Adams County, Wisconsin. The impoundment is slightly over 200 surface acres in size. Maximum depth is 24', with an average depth of 8'. During the summer of 2006 when this aquatic plant survey was conducted, the lake was at slightly lower level than usual due to drought and very hot weather. The dam impounds Fourteen-Mile Creek downstream upstream from Arrowhead Lake and Sherwood Lake, on its way to the Wisconsin River.

Upper Camelot Lake is accessible off of State Highway 13 by turning east onto County D. There are no public boat launches on Upper Camelot Lake. Heavy residential development around the lake is found along most of the lakeshore. Both the ground and surface watersheds extend into other counties to the east and north and contain both irrigated and non-irrigated agriculture. There are endangered or threatened resources in the watershed including the Karner Blue Butterfly, the Greater Prairie Chicken; the Long-Leaf Aster; and the natural communities of northern dry-mesic forest and alder thicket. Archeological sites reported in the Upper Camelot Lake surface watershed include an unnamed burial site in Adams County, as well as the Millard Smith Mound Group, Lake Huron

Group, Krushki Group, Town House Mounds, and Weymouth Group, all located in Waushara County.

A fishery inventory in October 2004 revealed that bluegills and largemouth bass are abundant in Upper Camelot Lake, although bluegills had a poor size structure (stunted growth); all other fish found, including black crappie, northern pike, pumpkinseed, yellow perch, and walleye, were scarce. In the 1970s, the lake was stocked with largemouth bass, walleye, northern pike and bluegills.

Soils in the Upper Camelot Lake surface watershed are sands of various slopes. Such soils tend to be excessively-drained, with infiltration of water being rapid to very rapid, and permeability also high. Such soils also usually have a low water-holding and low organic matter content, thus making them difficult to establish vegetation on. These soils tend to be easily eroded by both water and wind.

Efforts at controlling aquatic plant growth have included both chemical treatments and mechanical harvesting.

Year	Copper	Cutrine+	Aquathol	Hydrothol	Diquat	Rodeo	2,4-D	Silvex	AV-70
-	(lbs)	(gal)	(gal)	(gal)	(gal)	(gal)	(lbs)	-	-
1970	400		5		10			2	
1971	85		5		29.5			13	
1972	105				8				
1973	985				29.5				
1974	380				23				
1975	374		16.5		13				14
1976	130		70	100	16				17
1977	520		25	400	10		14		10.5
1978									
1979	400								
1980	250								
1984				30					
1985	75		26		5				
1986	265		24		4				
1987	210								
1988	1085				20				
1989	1000		15		10				
1990	270		15		21	6	10		
1991	375		12.5		4		10		
1992	350		20		12				
1993	200				15		10		
1994	150		38.25		22.75		10		
1995	355		52		21.75		10		
1996		32	15		15		10		
1997		46.5	3		3				
1999			5		5				
2000					30				
total	**7967**	**78.5**	**362.25**	**530**	**327.5**	**6**	**74**	**19**	**41.5**

Both copper in pounds and cutrine in gallons added copper to Upper Camelot Lake. Copper is an element and does not degrade any further. Copper is known to harm native mollusks (clams, mussels, snails) and invertebrates that serve as food for the fish. Hydrothol, added to Upper Camelot Lake between 1977 and 1984, has been implicated in damage to young fish.

Mechanical harvesting of aquatic plants in Upper Camelot Lake started in 1995 and has continued through 2006. The chart below shows the pounds of aquatic plant removed through mechanical harvesting through 2006. For 2005 and 2006, plant samples were taken to a laboratory to be tested for the amount of phosphorus in milligrams per kilogram of aquatic plants. This is also shown on the chart below.

Year	Lake Camelot (lbs)	Upper Camelot (lbs)	Phosphorus Removed (lbs)
1995	153,000		NA
1996	139,600		NA
1997	152,000		NA
1998	292,000		NA
1999		293,000	NA
2000		281,000	NA
2001		247,600	NA
2002		240,200	NA
2003		302,000	NA
2004		466,000	NA
2005		516,400	762.21
2006		784,600	212.21
total	736,600	3,130,800	974.42

An aquatic plant survey was by DNR staff in 2000. This survey found that that the plant-like algae, *Chara* spp (muskgrass), was the most frequently-occurring aquatic "plant" species in Upper Camelot Lake. Only *Chara* spp. occurred at more than 50% frequency. *Chara s*pp also had the highest density. On the lake overall, no aquatic species occurred at more than average density except *Chara* spp.   *Ceratophyllum demersum, Lemna minor, Myriophyllum sibiricum, Myriophyllum spicatum, Polygonum aquaticum, Potamogeton nodosus, Potamogeton pectinatus, Spirodela polyrhiza* and *Typha angustifolia* occurred at more than average density where they were present. Although two invasives, *Myriophyllum spicatum* (Eurasian watermilfoil) and *Potamogeton crispus* (Curly-Leaf Pondweed) were found in 2000, only *Myriphyllum spicatum* occurred at a high density and frequency.

Since the discovery of zebra mussels in Arrowhead Lake, the WDNR has been monitoring Upper Camelot Lake for any sign of infestation. As of 2006, no zebra mussels had been found in Upper Camelot Lake.

II. METHODS

Field Methods

The 2000 and 2006 studies were both based on the rake-sampling method developed by Jessen and Lound (1962), using stratified random transects. The shoreline was divided into 19 equal sections, with one transect placed randomly within each segment, perpendicular to the shoreline. The same transects were used for both studies.

One sampling site was randomly located in each depth zone (0-1.5'; 1.5'-5'; 5'-10'; 10'-20') along each transect. Using long-handled, steel thatching rakes, four rake samples were taken at each site. Samples were taken from each quarter around the boat. Aquatic species present on each rake were recorded and given a density rating of 0-5.

A rating of 1 indicates the species was present on 1 rake sample.

A rating of 2 indicates the species was present on 2 rake samples.

A rating of 3 indicates the species was present on 3 rake samples.

A rating of 4 indicates the species was present on 4 rake samples.

A rating of 5 indicates that the species was abundantly present on all rake samples.

A visual inspection and periodic samples were taken between transects to record the presence of any species that didn't occur at the raking sites. Gleason and Cronquist (1991) nomenclature was used in recording species found.

Shoreline type was also recorded at each transect. Visual inspection was made of 50' to the right and left of the boat along the shoreline, 35' back from the shore (so total view was 100' x 35'). Percent of land use within this rectangle was visually estimated and recorded.

Data Analysis:

The percent frequency (number of sampling sites at which it occurred/total number of sampling sites) of each species was calculated. Relative frequency (number of species occurrences/total of all species occurrences) was also calculated. The mean density (sum of species' density rating/number of sampling sites) was calculated for each species. Relative density (sum of species' density/total plant density) was also calculated. "Mean density where present "(sum of species' density rating/number of sampling sites at which species occurred) was calculated. Relative frequency and relative density results were summed to obtain a dominance value. Species diversity was measured by Simpson's Diversity Index.

The Average Coefficient of Conservatism and Floristic Quality Index were calculated as outlined by Nichols (1998) to measure plant community disturbance. A coefficient of Conservatism is an assigned value between 0 and 10 that measures the probability that the species will occur in an undisturbed habitat. The Average Coefficient of Conservatism is the mean of the coefficients for the species found in the lake. The coefficient of conservatism is used to calculate the Floristic Quality Index, a measure of a plant community's closeness to an undisturbed condition.

To measure the quality of the aquatic plant community, an Aquatic Macrophyte Index was determined using the method developed by Nichols et al (2000). This measurement looks at the following seven parameters and assigns each of them a number on a scale of 1-10: maximum depth of plant growth; percentage of littoral zone vegetated; Simpson's diversity index; relative frequency of submersed species; relative frequency of sensitive species; taxa number; and relative frequency of exotic species. The average total for the North Central Hardwoods lakes and impoundments is between 48 and 57.

III. RESULTS

Physical Data

The aquatic plant community can be impacted by several physical parameters. Water quality, including nutrients, algae and clarity, influence the plant community; the plant community in turn can modify these boundaries. Lake morphology, sediment composition and shoreline use also affect the plant community.

The trophic state of a lake is a classification of water quality (see Table 1). Phosphorus concentration, chlorophyll a concentration and water clarity data are collected and combined to determine a trophic state. **Eutrophic lakes** are very productive, with high nutrient levels and large biomass presence. **Oligotrophic lakes** are those low in nutrients with limited plant growth and small fisheries.

Mesotrophic lakes are those in between, i.e., those which have increased production over oligotrophic lakes, but less than eutrophic lakes; those with more biomass than oligotrophic lakes, but less than eutrophic lakes; those with a good and more varied fishery than either the eutrophic or oligotrophic lakes.

The limiting factor in most Wisconsin lakes, including Upper Camelot Lake, is phosphorus. Measuring the phosphorus in a lake system thus provides an indication of the nutrient level in a lake. Increased phosphorus in a lake will feed algal blooms and also may cause excess plant growth. **The 2004-2006 summer average phosphorus concentration in Upper Camelot Lake was 25.35 ug/ml.** This isjust about average for impoundments (30.0 mg/l). This concentration suggests that Upper Camelot Lake is likely to have some nuisance algal blooms, but not as frequently as many impoundments. This places Upper Camelot Lake in the "good" water quality section for impoundments, and in the "**mesotrophic**" level for phosphorus.

Chlorophyll a concentrations provide a measurement of the amount of algae in a lake's water. Algae are natural and essential in lakes, but high algal populations can increase water turbidity and reduce light available for plant growth. **The 2004-2006 summer average chlorophyll a concentration in Upper Camelot Lake was 10.526 ug/ml.** These chlorophyll a results place Upper Camelot Lake at the "**mesotrophic**" level with "fair" water quality results.

Water clarity is a critical factor for plants. If aquatic plants receive less than 2% of the surface illumination, they won't survive. Water clarity can be reduced by turbidity (suspended materials such as algae and silt) and dissolved organic chemicals that color or cloud the water. Water clarity is measured with a Secchi disk. **Average summer Secchi disk clarity in Upper Camelot Lake in 2004-2006 was 6.21'.** This is good water clarity, putting Upper Camelot Lake into the "**mesotrophic**" category for water clarity.

It is normal for all of these values to fluctuate during a growing season. They can be affected by human use of the lake, by summer temperature variations, by algae growth & turbidity, and by rain or wind events. Phosphorus tends to rise in early summer, than decline as late summer and fall progress. Chlorophyll a tends to rise in level as the water warms, then decline as autumn cools the water. Water clarity also tends to decrease as summer progresses, probably due to algae growth, then improve as fall approaches.

Table 1: Trophic States

Trophic State	Quality Index	Phosphorus	Chlorophyll a	Sechhi Disk
		(ug/ml)	(ug/ml)	(ft)
Oligotrophic	Excellent	<1	<1	>19
	Very Good	1 to 10	1 to 5	8 to 19
Mesotrophic	Good	**10 to 30**	5 to 10	**6 to 8**
	Fair	30 to 50	**10 to 15**	5 to 6
Eutrophic	Poor	50 to 150	15 to 30	3 to 4
Upper Camelot Lake		**25.35**	**10.526**	**6.21'**

According to these results, Upper Camelot Lake scores as **"mesotrophic"** in all three of the general parameters often used to gauge lake water. With such readings, moderate plant growth and occasional algal blooms would be expected.

A groundwater study done in 2000 by UW-Stevens Point staff found that the groundwater coming into Upper Camelot Lake showed with elevated reactive phosphorus and ammonium, suggesting nutrient inputs from around the lake (rather than from the upper watershed). A Limnological Investigation performed by the U.S. Army Corps of Engineers in 2000 indicated that Upper Camelot Lake served as a sink for total suspended solids and total phosphorus, but discharges more total nitrogen than it receives from the upper watershed. These studies indicated that internal phosphorus loading is probably occurring in Upper Camelot Lake, which increases the likelihood of aquatic plant growth and algae occurrence.

Lake morphology is an important factor in distribution of lake plants. Duarte & Kalff (1986) determined that the slope of a littoral zone could explain 72% of the observed variability in the growth of submerged plants. Gentle slopes support higher plant growth than steep slopes (Engel 1985).

Upper Camelot Lake is a narrow lake that lies at the beginning of a series of lakes that are originally fed by a very large, multi-county stream system. Much of the lake is shallow, although there are some areas of steeper drop-offs within the lake near the dam. With good water clarity and shallow depths, plant growth may be favored in much of Upper Camelot Lake, since the sun reaches much of the sediment to stimulate plant growth.

Sediment composition can also affect plant growth, especially those rooted. The richness or sterility and texture of the sediment will determine the type and abundance of macrophyte species that can survive in a particular location.

Table 2: Sediment Composition—Upper Camelot Lake

Sediment	Type	Zone 1	Zone 2	Zone 3	Zone 4	Overall
Hard	Sand	70.00%	40.00%	30.00%	27.30%	43.66%
Mixed	Sand/Muck			15.00%	9.10%	5.64%
	Sand/Peat		5.00%		9.10%	2.82%
Soft	Muck	10.00%	10.00%	30.00%	36.30%	19.72%
	Peat		20.00%	20.00%	18.20%	14.08%
	Peat/Muck		10.00%	5.00%		4.22%
	Silt	20.00%	15.00%			9.86%

Most of the sediment in Upper Camelot Lake is hard, with little natural fertility and low available water holding capacity. Although such sediment may limit growth, most hard sediment sites in Upper Camelot Lake were vegetated. 97.2% sample sites were vegetated in Upper Camelot Lake, no matter what the sediment. The few unvegetated sites appeared to have had vegetation cleared by hand harvesting.

Shoreline land use often strongly impacts the aquatic plant community and thus the entire aquatic community. Impacts can be caused by increased erosion and sedimentation and higher run-off of nutrients, fertilizers and toxins applied to the land. Such impacts occur in both rural and residential settings.

Some type of natural vegetated shoreline covered only 26.25% of the lake shoreline in 2006. Disturbed shorelines—including bare sand, traditional cultivated lawn, hard structure (piers, decks, seawalls, etc.) and rock riprap--were the most frequently-occurring shore, covering 73.75% of the shore of Upper Camelot Lake. Cultivated lawn had the highest coverage—nearly one half the shoreline.

Table 3: Shoreland Land Use—Upper Camelot Lake—2000 and 2006

		2006 Frequency	2000 Frequency	2006 Coverage	2000 Coverage
Vegetated	Herbaceous	45.00%	30.00%	13.00%	6.00%
Shoreline	Shrub	20.00%	15.00%	2.00%	2.25%
	Wooded	25.00%	15.00%	11.25%	13.00%
Disturbed	Bare Sand/Eroded	70.00%	50.00%	10.75%	15.50%
Shoreline	Cultivated Lawn	85.00%	85.00%	44.00%	55.50%
	Hard Structure	60.00%	20.00%	8.50%	3.25%
	Pavement	0	0.00%	0%	2.25%
	Rock riprap	60.00%	40.00%	11.00%	4.50%

In the past two years, a concerted effort has been made on Camelot Lake to install shore protection and/or restoration practices. Perhaps this is the reason why cultivated lawn and eroded bare shore had slightly less coverage in 2006 than in 2000 (44% vs. 55%) and why there was slightly more vegetated shore coverage in 2006 than in 2000 (26.25% vs. 21.25%). However, the amount of coverage by rock riprap and hard structure increased since 2000.

Macrophyte Data

SPECIES PRESENT

Of the 29 species found in Upper Camelot Lake, 27 were native and 2 were exotic invasives. In the native plant category, 9 were emergent, 1 was a floating-leaf plant, 1 was free-floating and 16 were submergent species. Two exotic invasives, *Myriophyllum spicatum* (Eurasian Watermilfoil) and *Potamogeton crispus* (Curly-Leaf Pondweed) were found.

Comparing the species found in 2006 to those reported in 2000, some changes are evident. Only one plant was found in 2000 that was not found in 2006 included: *Lemna minor* (free-floating). Several plants found in 2006 were not found in 2000: *Eleocharis smallii* (emergent); *Myriophyllum heterophyllum* (submergent); *Myriophyllum sibiricum* (submergent); *Potamogeton gramineus* (submergent); *Potamogeton illinoensis* (submergent); *Potamogeton natans* (submergent); *Sagittaria latifolia* (emergent); *Salix spp* (emergent); *Scirpus validus* (emergent); and *Typha angustifolia* (emergent). Since the 2006 plant survey was conducted in August, past primary growing season for *Potamogeton crispus*, it is possible that *P. crispus* was present in greater occurrence earlier in the summer in 2006, since it was found in 2000.

Table 4—Plants Found in Upper Camelot Lake, 2006

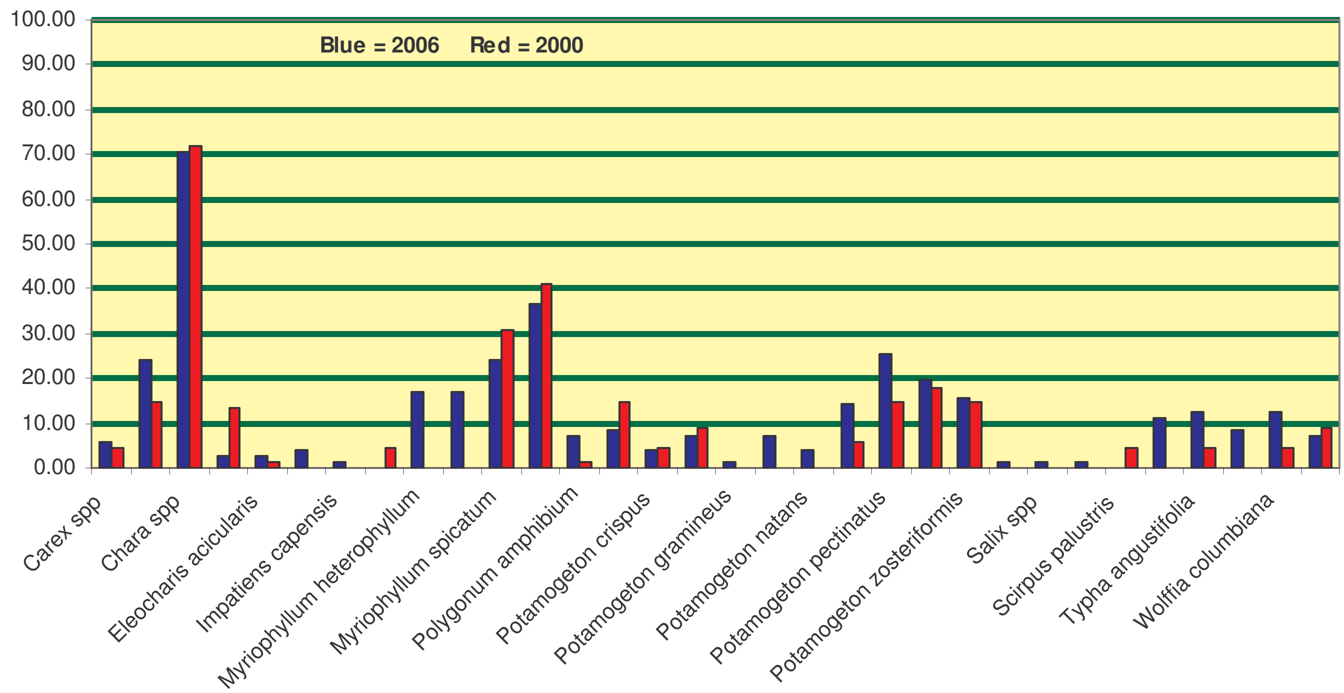
Scientific Name	Common Name	Type	Found in 2000
Carex spp	Sedge	Emergent	
Cerataphyllum demersum	Coontail	Submergent	x
Chara spp	Muskgrass	Submergent	x
Elodea canadensis	Waterweed	Submergent	x
Eleocharis acicularis	Needle Spikerush	Emergent	x
Eleocharis smallii	Marsh Spikerush	Emergent	
Impatiens capensis	Jewelweed	Emergent	
Myriophyllum heterophyllum	Various-Leafed Watermilfoil	Submergent	
Myriophyllum sibiricum	Northern Milfoil	Submergent	
Myriophyllum spicatum	Eurasian Watermilfoil	Submergent	x
Najas flexilis	Bushy Pondweed	Submergent	x
Polygonum amphibium	Water Smartweed	Floating-Leaf	x
Potamogeton amplifolius	Large-Leaf Pondweed	Submergent	x
Potamogeton crispus	Curly-Leaf Pondweed	Submergent	x
Potamogeton foliosus	Leafy Pondweed	Submergent	x
Potamogeton gramineus	Variable Pondweed	Submergent	
Potamogeton illioensis	Illinois Pondweed	Submergent	
Potamogeton natans	Floating-Leaf Pondweed	Submergent	
Potamogeton nodusus	Long-Leaf Pondweed	Submergent	x
Potamogeton pectinatus	Sago Pondweed	Submergent	x
Potamogeton pusillus	Small Pondweed	Submergent	x
Potamogeton zosteriformis	Flat-Stem Pondweed	Submergent	x
Sagittaria latifolia	Arrowhead	Emergent	
Salix spp	Willow	Emergent	
Schoenoplectus pungens	Common Threesquare	Emergent	
Scirpus validus	Soft-Stem Bulrush	Emergent	
Vallisneria americana	Water Celery	Submergent	
Wolffia columbiana	Watermeal	Free-Floating	x
Zosterella dubia	Water Stargrass	Submergent	x

Of the plants on this list, several are likely to increase in frequency and/or density if there are regular drawdowns: *Carex* spp (emergent); *Najas flexilis* (submergent); *Potamogeton crispus* (submergent exotic); *Potamogeton pectinatus* (submergent); *Potamogeton zosteriformis* (submergent); and *Salix* spp (emergent). Some of the plants on this list tend to decrease with drawdowns: *Chara* spp (submergent); *Myriophyllum sibiricum* (submergent); *Myriophyllum spicatum* (submergent exotic); and *Vallisneria americana* (submergent). In general, regular drawdowns will tend to encourage the plants that can handle frequent disturbances and will also tend to reduce the diversity of the aquatic plant community.

FREQUENCY OF OCCURRENCE

Chara spp was the most frequently-occurring "plant" in Upper Camelot Lake in 2006, as it was in 2000. No species but *Chara* spp reached a frequency of 50% or greater in the lake overall in either 2000 or 2006. When reviewing the occurrence frequency within vegetated areas in 2006, only *Chara* spp reached an occurrence frequency over 50%; next closest was *Najas flexilis* at 36.62% occurrence within vegetated beds. The same pattern was followed in 2000, with *Najas flexilis* occurring at 45.90% where present.

Chart 1: Occurrence Frequency

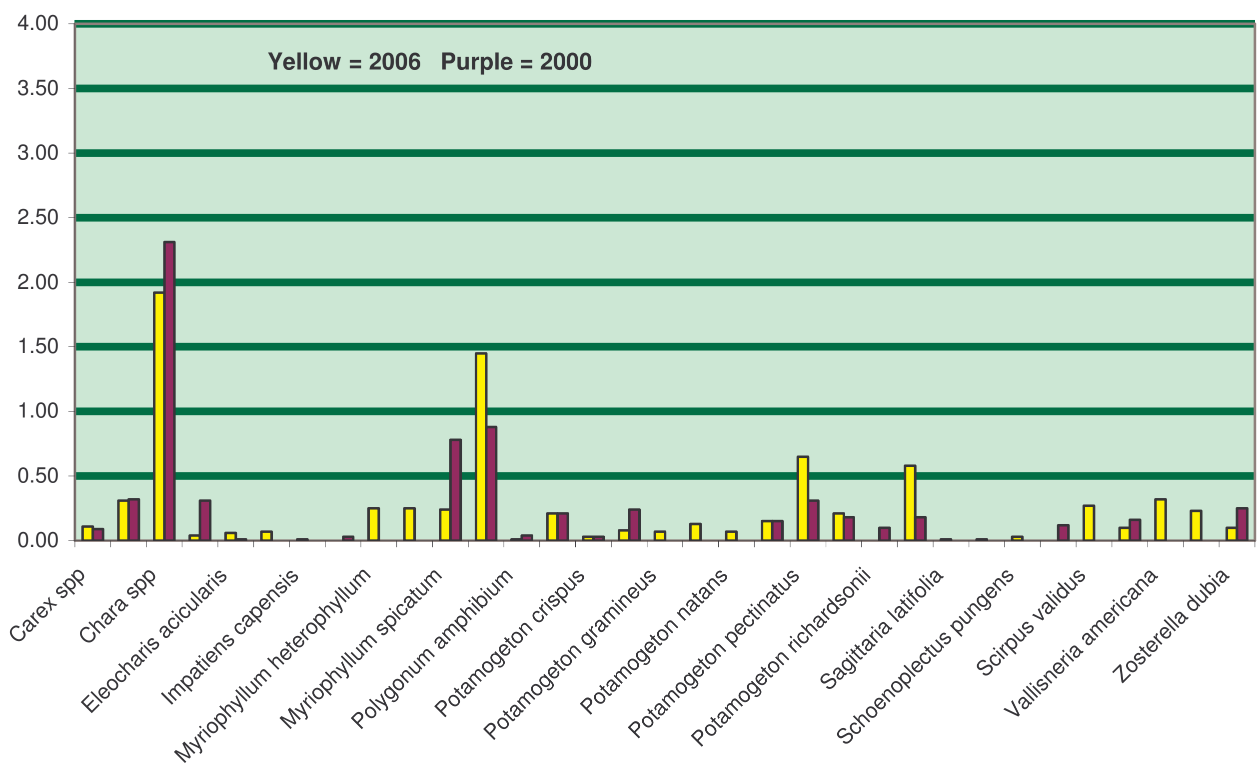


Filamentous algae were found at 8.22% of the sample sites in 2006 and at 29.51% of the sites in 2000.

DENSITY OF OCCURRENCE

Chara spp was also the densest plant in 2006 in Upper Camelot Lake, with a mean density of 1.92 (on a scale of 1 to 4). In the lake overall, none of the aquatic vegetation had a mean density of over 2.0, meaning none occurred at more than average, in 2006. In 2006, there were no species at more than average density in Depth Zones 1, 2 and 4. Zone 3 had *Chara* spp at 2.15 density. *Chara* spp was the densest occurring plant in Zones 1, 2 and 3. In Zone 4, *Najas flexilis* occurred at the highest density.

Chart 2: Mean Density

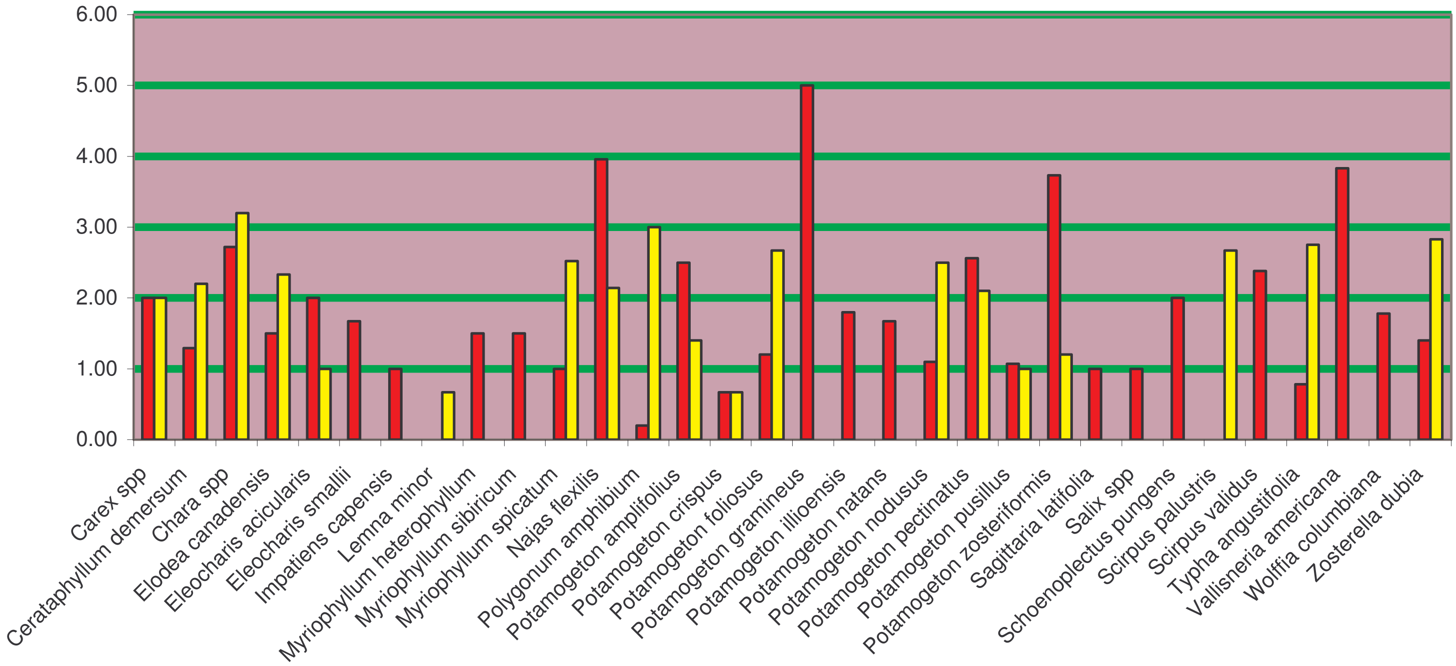


However, when looking at the “mean density where presen”, seven plants in addition to *Chara* spp had a more than average density of occurrence in 2006: *Najas flexilis; Potamogeton amplifolius; Potamogeton gramineus, Potamogeton pectinatus, Potamogeton zosteriformis, Scirpus validus,* and *Vallisneria americana.* Except for *Scirpus validus,* all of these plants are submergent plants. These figures indicate several species of the lake have higher than average growth form density that can interfere with fish habitat and recreational use.

In 2000, more species occurred at higher than average “density where present” than in 2006. In 2000, there eleven plants in addition to *Chara* spp in 2000 that had more than average density where present: *Ceratophyllum demersum; Elodea canadensis; Myriophyllum spicatum; Najas flexilis; Potamogeton amphibium; Potamogeton foliosus; Potamogeton nodosus; Potamogeton pectinatus; Scirpus palustris; Typha angustifolia;* and *Zosterella dubia.* Nine of these are submergent plants.

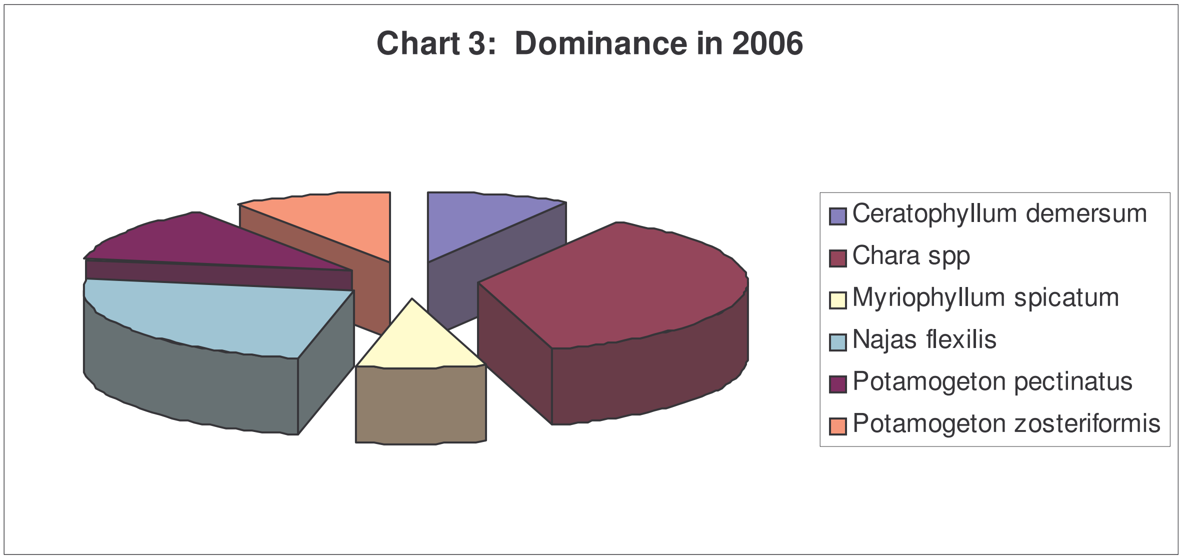
Several other plants found in 2006 are on the verge of more than average densities with “mean densities where present” of 2.00: *Carex* spp*; Eleocharis acicularis; Schoenoplectus pungens.* All of these are emergent plants and occur rarely in Upper Camelot Lake.

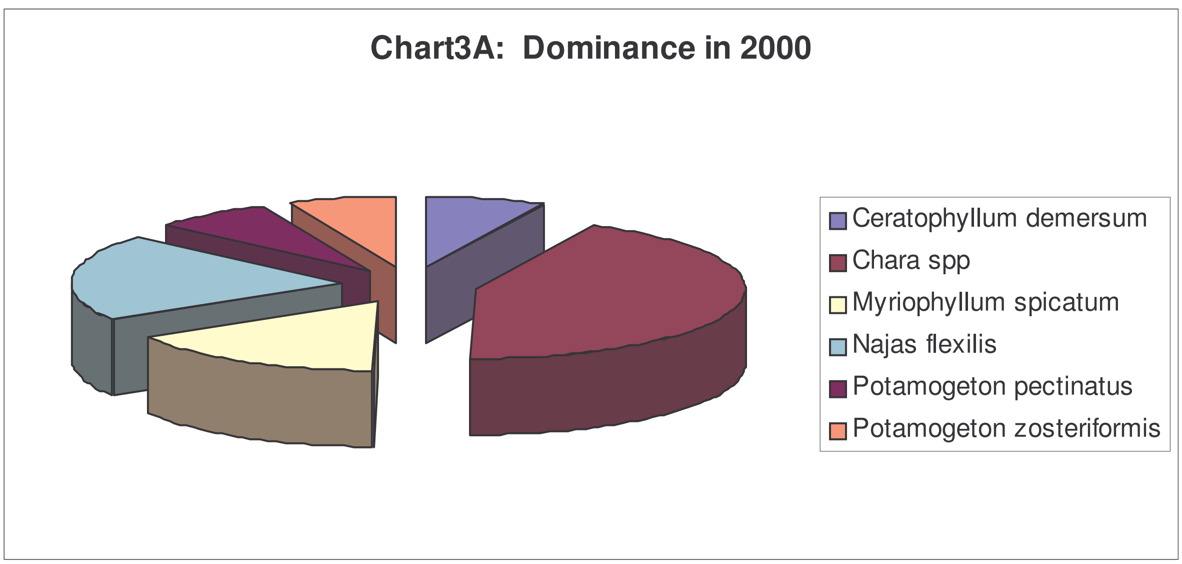
Chart 2A: Mean Density Where Present



DOMINANCE

Relative frequency and relative density are combined into a dominance value that demonstrates how dominant a species is within its aquatic plant community. Based on dominance value, *Chara* spp was the dominant aquatic "plant" species in Upper Camelot Lake in 2006, followed by *Najas flexilis*. *Chara* spp dominated the aquatic plant community of Upper Camelot Lake in 2000, with *Najas flexilis* coming in second.





Myriophyllum spicatum and *Phalaris arundinacea*, the exotics found Upper Camelot Lake, were not present in high frequency, high density or high dominance in either year, although *Myriophyllum spicatum* had a greater presence in 2000.

In both 2000 and 2006, *Chara* spp was dominant in all four individual depth zones.

DISTRIBUTION

Aquatic plants occurred at 97.2% of the sample sites in Upper Camelot Lake to a maximum rooting depth of 13'. This is more coverage than the 89.7% figure of 2000, when the maximum rooting depth was also 13'. Free-floating plants were found in the Zones 1 and 3 in 2006, but only in the shallowest zone in 2000. Filamentous algae were found in all sampling zones in 2006, but only in the three shallowest zones in 2000.

Secchi disc readings are used to predict maximum rooting depth for plants in a lake (Dunst, 1982). Based on the summer 2004-2006 Secchi disc readings, the predicted maximum rooting depth in Upper Camelot Lake would be **10.31 feet.** During both the 2000 and the 2006 aquatic plant surveys, rooted plants were found at a depth of **13'**, i.e., rooted plants were at a depth substantially more than that to be expected by Dunst calculations.

In 2006, the 5'-10' depth zone (Zone 3) produced the highest total occurrence of plant growth, followed closely by Depth Zone 1. There was then a drop in total occurrence in Zone 2, then a sharp drop to Zone 4. The pattern was slightly different in 2000: Depth Zone 3 still had the highest total occurrence, then a drop in frequency in Depth Zones 1 and 2, which were close to one another, than a sharp drop to occurrence in Zone 4.

For total plant density in 2006, Depth Zone 1 had the most total density, and Depth Zone 3 had denser growth than Depth Zone 2. A sharp drop in density characterized Depth Zone 4. In 2000, Depth Zone 3 had the highest total occurrence, followed by Zones 1 and 2, which were close to one another. Zone 4 had the least dense growth. Both total occurrence and density of plant growth have increased since 2000.

Chart 5: Zone Occurrence

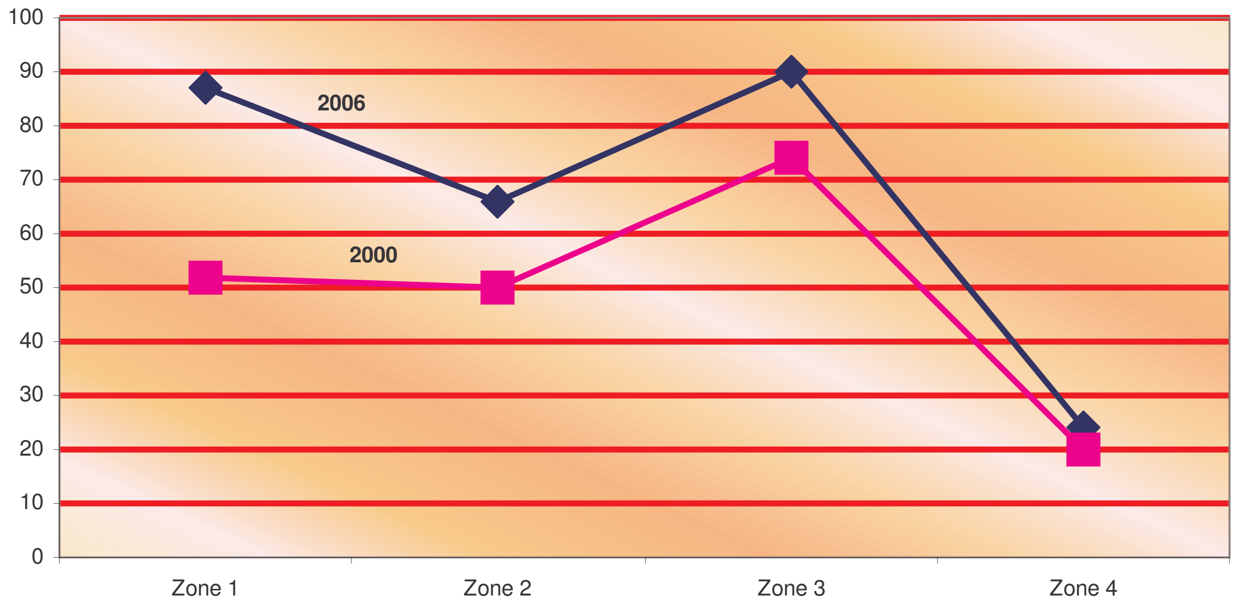
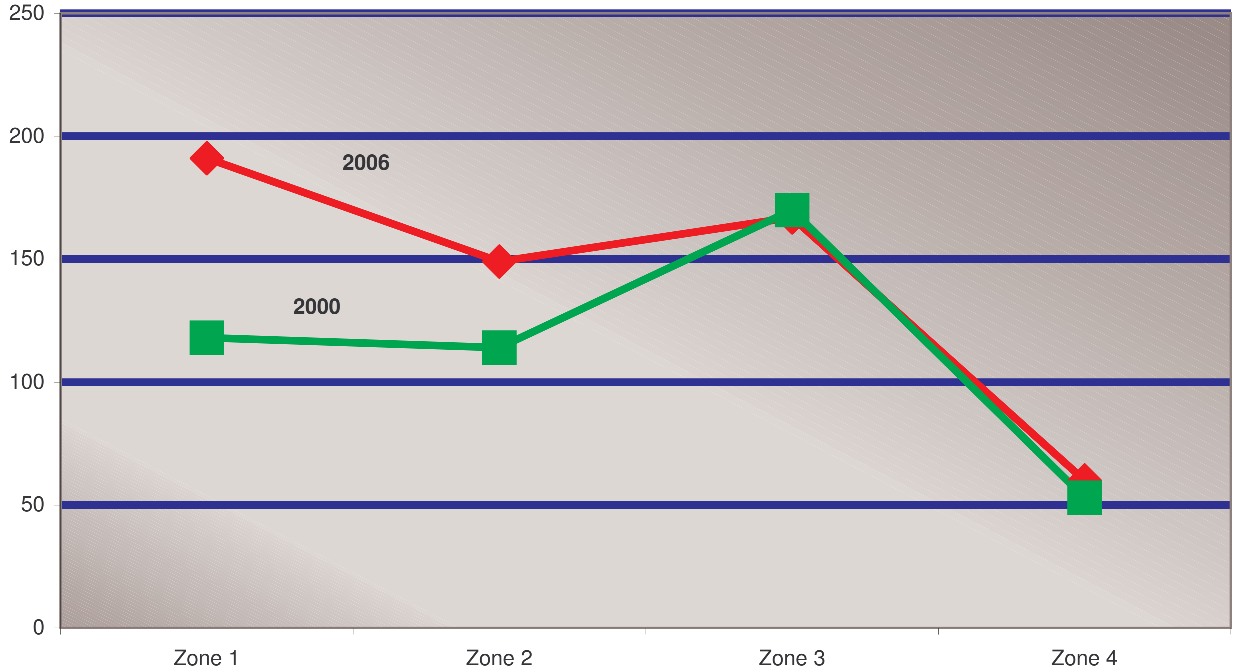


Chart 5: Zone Density



Species richness increased slightly between 2000 and 2006, with the biggest increase in richness found in Depth Zone 1 (0-1.5').

	2006	2000
Zone 1	4.58	3.47
Zone 2	3.4	2.78
Zone 3	4.5	3.7
Zone 4	2.36	2.5
Overall	3.87	3.21

THE COMMUNITY

The Simpson's Diversity Index for Upper Camelot Lake in 2006 was .93, a good species diversity. A rating of 1.0 would mean that each plant in the lake was a different species (the most diversity achievable). This places it in the upper quartile for Simpson's Diversity Index readings for both North Central Hardwood Forest and all Wisconsin lakes. This is considerably higher than the Simpson's

Diversity Index for 2000, which was .88. The 2006 AMCI for Upper Camelot Lake is 58, placing it just above the average range for North Central Wisconsin Lakes and all Wisconsin Lakes. The AMCI value for 2000, .52, is in the average range.

Table 5: Aquatic Macrophyte Community Index-2006 & 2000

AMCI Category	2000 Result	2000 Value	2006 Result	2006 Value
Max. Rooting Depth	13'	7	13'	7
% Littoral Zone Veg.	89.7%	10	97.2%	10
% Submersed Species	91%	8	81%	10
% Exotic Species	13%	4	7%	5
% Sensitive Species	15%	7	10%	6
Taxa #	18	8	30	10
Simpson's Index	0.88	8	0.93	10
		52		58

Using the AMCI index, considerable change has occurred in Upper Camelot Lake between 2000 and 2006.

The presence of two invasive, exotic species could be a significant factor in the future. Currently, none of the exotic species appear to be taking over the aquatic plant community, but *Myriophyllum spicatum* had an occurrence frequency of nearly 24% in 2006, despite the long history of both chemical and mechanical control efforts. This plant must continue to be monitored, since its tenacity and ability to spread to large areas fairly quickly could make it a danger to the diversity of Upper Camelot Lake's current aquatic plant community. Although some *Potamogeton crispus* was found in Upper Camelot Lake in 2006, it was not at a high frequency or density. Since the 2006 survey was conducted in August, it is possible that this lake had more *Potamogeton crispus* that had simply died off earlier in the summer, since *P. crispus* tends to be an early-season plant. The lake should also be monitored for this invasive.

An Average Coefficient of Conservatism and a Floristic Quality Index calculation were performed on the field results. Technically, the Average Coefficient of Conservatism measures the community's sensitivity to disturbance, while the Floristic Quality Index measures the community's closeness to an undisturbed condition. Indirectly, they measure past and/or current disturbance to the particular community.

Previously, a value was assigned to all plants known in Wisconsin to categorize their probability of occurring in an undisturbed habitat. This value is called the plant's Coefficient of Conservatism. A score of 0 indicates a native or alien opportunistic invasive plant. Plants with a value of 1 to 3 are widespread native plants. Values of 4 to 6 describe native plants found most commonly in early successional ecosystem. Plants scoring 6 to 8 are native plants found in stable climax conditions. Finally, plants with a value of 9 or 10 are native plants found in areas of high quality and are often rare, endangered or threatened. In other words, the lower the numerical value a plant has, the more likely it is to be found in disturbed areas.

The Average Coefficient of Conservatism in Upper Camelot Lake in 2006 was 4.63, down very slightly from 4.68 in 2000. This puts this lake in the lowest quartile for Wisconsin Lakes (average 6.0) and for lakes in the North Central Hardwood Region (average 5.6). The aquatic plant community in Upper Camelot Lake is in the category of those lakes most tolerant of disturbance, probably due to selection by a series of past disturbances.

The Floristic Quality Index of the aquatic plant community in Upper Camelot Lake of 25.38 in 2006 is above average for Wisconsin Lakes (average 22.2) and the North Central Hardwood Region (average 20.9). This suggests that the plant community in Upper Camelot Lake is farther from an undisturbed condition than the average lake in Wisconsin overall and in the North Central Hardwood Region. The 2000 figure of 20.42 was slightly below average. The Floristic Quality Index has increased between 2000 and 2006, suggesting some small progress in overall aquatic plant health may be occurring. Using either the Average Coefficient of Conservatism or the Floristic Quality Index scales, the aquatic plant community in Upper Camelot Lake apparently has been impacted by a more than average amount of disturbance.

"Disturbance" is a term that covers many disruptions to a natural community. It includes physical disturbances to plant beds such as boat traffic, plant harvesting, chemical treatments, dock and other structure placements, shoreline development and fluctuating water levels. Indirect disturbances like sedimentation, erosion, increased algal growth, and other water quality impacts will also negatively affect an aquatic plant community. Biological disturbances such as the introduction of non-native and/or invasive species (such as the Eurasian Watermilfoil, Reed Canarygrass and Curly-Leaf Pondweed found here), destruction of plant beds, or changes in aquatic wildlife can also negatively impact an aquatic plant community. Shore development and sediment deposition can also reduce the quality of the aquatic plant community.

Out of the 20 transects sampled on Camelot Lake, only one site was totally naturally vegetated. Therefore, no statistical evaluation comparing the aquatic macrophyte communities at disturbed vs. natural shores was appropriate.

IV. DISCUSSION

Based on water clarity, chlorophyll and phosphorus data, Upper Camelot Lake is a mesotrophic impoundment with good water clarity and good water quality. This trophic state should support substantial plant growth and occasional algal blooms.

Sufficient nutrients (trophic state), fair water clarity, hard water, shallow lake, and nutrient-rich input from heavy shore development at Upper Camelot Lake favor plant growth. Despite the sometime limiting effect of sand sediments on aquatic plant growth, over 97% of the lake is vegetated, suggesting that even the heavily-sandy sediments in Upper Camelot Lake hold sufficient nutrients to maintain aquatic plant growth.

Historically, many aquatic plant treatments in Upper Camelot Lake were chemical. There has been mechanical harvesting to try to reduce plant growth in the last 10 years or so. A continued regular schedule and pattern of machine harvesting will help in removing vegetation from the lake and may help with nutrient reduction. The harvesting should also be designed to set back the growth of Eurasian Watermilfoil, not spread it further. It might also help to skim off the filamentous algae.

The lake has some mixture of structure of emergent, free-floating, floating-leaf and submerged plants. Of the 20 species found in Upper Camelot Lake, 27 were native and 2 were exotic invasives. However, emergent and floating-leaf plants are very important for habitat, so the facts that floating-leaf vegetation is very sparse and emergent plants declined in coverage are causes for concern. In the native plant category, 9 were emergent, 1 was a floating-leaf plant, 1 was free-floating and 16 were submergent species. Two exotic invasives, *Myriophyllum spicatum* (Eurasian Watermilfoil) and *Potamogeton crispus* (Curly-Leaf Pondweed) were found.

Chara spp was the most frequently-occurring "plant" in Upper Camelot Lake in 2006, as it was in 2000. No species but *Chara* spp reached a frequency of 50% or greater in the lake overall in either 2000 or 2006. The same pattern was followed in 2000, with *Najas flexilis* occurring at 45.90% where present.

Chara spp was also the densest plant in 2006 in Upper Camelot Lake, with a mean density of 1.92 (on a scale of 1 to 4). In the lake overall, none of the aquatic vegetation had a mean density of over 2.0, meaning none occurred at more than average, in 2006. However, when looking at the "mean density where present", seven plants in addition to *Chara* spp had a more than average form of growth in 2006: *Najas flexilis; Potamogeton amplifolius; Potamogeton gramineus, Potamogeton pectinatus, Potamogeton zosteriformis, Scirpus validus,* and *Vallisneria americana.* Except for *Scirpus validus,* all of these plants are submergent plants. These figures indicate several species of the lake have higher than average growth density that can interfere with fish habitat and recreational use.

The very few shoreline areas of native vegetation and wetlands on the lake should be preserved as they are to maintain habitat and to serve as a buffer for that area.

Studies have suggested that runoff from natural land is substantially less than that of developed areas. There are also some areas of deep erosion on steep banks that need to be addressed to prevent tree fall (and related root ball removal from bank) and bank preservation. Shoreline restoration of native vegetation is badly needed on Upper Camelot Lake.

The Simpson's Diversity Index Upper Camelot Lake in 2006 was .93, an indication of very good species diversity. A rating of 1.0 would mean that each plant in the lake was a different species (the most diversity achievable). This places it in the upper quartile for Simpson's Diversity Index readings for both North Central Hardwood Forest and all Wisconsin lakes. The 2006 AMCI for Upper Camelot Lake is 55, placing it in the average range for North Central Wisconsin Lakes and all Wisconsin Lakes.

Some type of native vegetated shoreline covered only 26.25% of the lake shoreline in 2006. Disturbed shorelines—including bare sand, traditional cultivated lawn, hard structure (piers, decks, seawalls, etc.) and rock riprap--were the most frequently-occurring shore, covering 73.75% of the shore of Upper Camelot Lake.

Looking at the results from the 2000 survey and those from 2006 shows some changes in the aquatic plant community. There were more species found in 2006, and the structure of the aquatic plant community has changed with less emergent cover. There is only one species of floating-leaf plants, which provide habitat and cover for fish and invertebrates. Free-floating plants, indicators of nutrient enrichment and poor water clarity, have substantially increased since 2000.

Changes in the Aquatic Plant Community 2000 to 2006

Upper Camelot	2000	2006	Change	%Change
Number of Species	19	30	11	**57.9%**
Maximum Rooting Depth in Feet	13.0	13.0	0	0.0%
% of Littoral Zone Unvegetated	10.3%	2.8%	-0.075	-72.8%
%Sites/Emergents	6.56%	5.80%	-9.19	-140.09.%
%Sites/Free-floating	1.64%	11.59%	0.29	**1768.3%**
%Sites/Submergents	100.00%	100.00%	-0.09	-9.0%
%Sites/Floating-leaf	0.00%	1.87%	1.82	**364.0%**
Simpson's Diversity Index	0.89	0.93	0.04	**4.5%**
Species Richness	3.21	3.87	0.66	**20.6%**
Floristic Quality	20.42	25.38	4.96	**24.3%**
Average Coefficient of Conservatism	4.68	4.63	-0.05	-1.1%
AMCI Index	52	58	6.00	**11.5%**

Further, when calculating the coefficient of similarity between the 2000 and 2006 surveys, they score as statistically similar in terms of frequency of occurrence, but dissimilar in terms of relative frequency. Based on frequency of occurrence, the aquatic plant communities of the two years are just over 75% similar. Similarity percentages of 75% or more are considered statistically similar. But using relative frequency, the score is only 68% similar.

Overall, most species have not changed in frequency, but a few species have shifted their standing in the community; for example, *Ceratophyllum demersum* and *Potamogeton pectinatus* have increased, but *Elodea canadensis* and *Potamogeton amplifolius* have increased. It is worth noting that the report on the 2000 aquatic plant surveys mentioned the low level of emergent plants in Upper Camelot Lake. The 2006 survey shows that occurrence and cover of emergent plants are were still scarce in Upper Camelot Lake, scarcer than they were in 2000, but there were more species of emergent plants in 2006. Some valuable pondweeds and water smartweed have increased; *Elodea canadensis*, *Myriophyllum spicatum,* and some sensitive pondweeds have declined substantially. Water clarity may have improved, but disturbance level is still high.

Changes in Aquatic Plant Species

Species		2000	2006	Year1-2	%
					Change
Carex spp	Frequency	4.41%	5.63%	0.0122	21.7%
	Mean Density	0.09	0.11	0.02	18.2%
	Dom. Value	0.03	0.03	0	0.0%
				0	
Ceratphyllum demersum	Frequency	14.71%	23.94%	0.0923	38.6%
	Mean Density	0.32	0.31	-0.01	-3.2%
	Dom. Value	0.1	0.1	0	0.0%
				0	
Chara spp	Frequency	72.06%	70.42%	-0.0164	-2.3%
	Mean Density	2.31	1.92	-0.39	-20.3%
	Dom. Value	0.6	0.43	-0.17	-39.5%
				0	
Eleocharis acicularis	Frequency	1.47%	2.82%	0.0135	47.9%
	Mean Density	0.01	0.06	0.05	83.3%
	Dom. Value	0.01	0.01	0	0.0%
				0	

Eleocharis smallii	Frequency	0	4.23%	0.0423	100.0%
	Density	0	0.07	0.07	100.0%
	Imp. Val.	0	0.02	0.02	100.0%
				0	
Elodea canadensis	Frequency	13.24%	2.82%	-0.1042	-369.5%
	Density	0.31	0.04	-0.27	-87.1%
	Imp. Val.	0.09	0.01	-0.08	-88.9%
Impatiens capensis	Frequency	0.00%	1.41%	0.0141	100.0%
	Density	0	0.01	0.01	100.0%
	Imp. Val.	0	0.01	0.01	100.0%
Lemna minor	Frequency	4.41%	0	-0.0441	-100.0%
	Density	0.03	0	-0.03	-100.0%
	Imp. Val.	0.02	0	-0.02	-100.0%
Myriophyllum heterophyllum	Frequency	0	16.90%	0.169	100.0%
	Density	0	0.25	0.25	100.0%
	Imp. Val.	0	0.08	0.08	100.0%
Myriophyllum sibiricum	Frequency	0	16.90%	0.169	100.0%
	Density	0	0.25	0.25	100.0%
	Imp. Val.	0	0.08	0.08	100.0%
Myriophyllum spicatum	Frequency	30.88%	23.94%	-0.0694	-22.5%
	Density	0.78	0.24	-0.54	-69.2%
	Imp. Val.	0.22	0.09	-0.13	-59.1%
Najas flexilis	Frequency	41.18%	36.62%	-0.0456	-11.1%
	Density	0.88	1.45	0.57	64.8%
	Imp. Val.	0.28	0.28	0	0.0%
Polygonum amphibium	Frequency	1.47%	7.04%	0.0557	378.9%
	Density	0.04	0.01	-0.03	-75.0%
	Imp. Val.	0.01	0.02	0.01	100.0%
Potamogeton amplifolius	Frequency	14.71%	8.45%	-0.0626	-42.6%
	Density	0.21	0.21	0	0.0%

	Imp. Val.	0.08	0.05	-0.03	-37.5%
Potamogeton crispus	Frequency	3.00%	4.23%	0.0123	41.0%
	Density	0.03	0.03	0	0.0%
	Imp. Val.	0.02	0.01	-0.01	-50.0%
Potamogeton foliosis	Frequency	24.00%	7.04%	-0.1696	-70.7%
	Density	0.24	0.08	-0.16	-66.7%
	Imp. Val.	0.07	0.03	-0.04	-57.1%
Potamogeton gramineus	Frequency	0	1.41%	0.0141	100.0%
	Density	0	0.07	0.07	100.0%
	Imp. Val.	0	0.01	0.01	100.0%
Potamogeton illinoensis	Frequency	0	7.04%	0.0704	100.0%
	Density	0	0.13	0.13	100.0%
	Imp. Val.	0	0.03	0.03	100.0%
Potamogeton natans	Frequency	0	4.23%	0.0423	100.0%
	Density	0	0.07	0.07	100.0%
	Imp. Val.	0	0.02	0.02	100.0%
Potamogeton nodosus	Frequency	5.88%	14.08%	0.082	139.5%
	Density	0.15	0.15	0	0.0%
	Imp. Val.	0.04	0.06	0.02	50.0%
Potamgeton pectinatus	Frequency	14.71%	25.35%	0.1064	72.3%
	Density	0.31	0.65	0.34	109.7%
	Imp. Val.	0.1	0.15	0.05	50.0%
Potamgeton pusillus	Frequency	17.65%	19.72%	0.0207	11.7%
	Density	0.18	0.21	0.03	16.7%
	Imp. Val.	0.09	0.08	-0.01	-11.1%
Potamogeton zosteriformis	Frequency	18.17%	15.49%	-0.0268	-14.7%
	Density	0.18	0.58	0.4	222.2%
	Imp. Val.	0.09	0.11	0.02	22.2%
Sagittaria latifolia	Frequency	0	1.41%	0.0141	100.0%

	Density	0	0.01	0.01	100.0%
	Imp. Val.	0	0.01	0.01	100.0%
Salix spp	Frequency	0	1.41%	0.0141	100.0%
	Density	0	0.01	0.01	100.0%
	Imp. Val.	0	0.01	0.01	100.0%
Schoenoplectus pungens	Frequency	0	1.41%	0.0141	100.0%
	Density	0	0.03	0.03	100.0%
	Imp. Val.	0	0.01	0.01	100.0%
Scirpus palustris	Frequency	4.41%	0	-0.0441	-100.0%
	Density	0.12	0	-0.12	-100.0%
	Imp. Val.	0.02	0	-0.02	-100.0%
Scirpus validus	Frequency	0	11.27%	0.1127	100.0%
	Density	0	0.27	0.27	100.0%
	Imp. Val.	0	0.06	0.06	100.0%
Typha angustifolia	Frequency	5.88%	12.68%	0.068	115.6%
	Density	0.16	0.1	-0.06	-37.5%
	Imp. Val.	0.02	0.05	0.03	150.0%
Vallisneria americana	Frequency	0	8.45%	0.0845	100.0%
	Density	0	0.32	0.32	100.0%
	Imp. Val.	0	0.06	0.06	100.0%
Wolffia columbiana	Frequency	0.00%	12.68%	0.1268	100.0%
	Density	0	0.23	0.23	100.0%
	Imp. Val.	0	0.06	0.06	100.0%
Zosterella dubia	Frequency	8.82%	7.04%	-0.0178	-20.2%
	Density	0.25	0.1	-0.15	-60.0%
	Imp. Val.	0.07	0.03	-0.04	-57.1%

V. CONCLUSIONS

Upper Camelot Lake is a mesotrophic impoundment with good water quality and water clarity. Disturbance is above average as measured by the Average Coefficient of Conservatism of the aquatic plant community in Upper Camelot Lake is below average for Wisconsin lakes and for lakes in the North Central Hardwood region, as is the Floristic Quality Index. The quality of the aquatic plant community is average as measured by the AMCI for both North Central Hardwood Region and all Wisconsin lakes. Filamentous algae are present. Structurally, the aquatic plant community contains very few emergent plants or floating-leaf rooted plants. Submergent plants dominate the aquatic plant community in this lake.

Vegetation of the littoral zone increased 7.5%, so that over 97% of the zone is now vegetated. The potential for plant growth at all depths of the lake is present, even with many of the lake sediments sandy. This cover of aquatic plants is considerably over the recommended vegetation percentage for healthiest fish population (50%-85%).

Chara spp was the most frequently-occurring “plant” in Upper Camelot Lake in 2006, as it was in 2000. No species but *Chara* spp reached a frequency of 50% or greater in the lake overall in either 2000 or 2006. The same pattern was followed in 2000, with *Najas flexilis* occurring at 45.90% where present.

Chara spp was also the densest plant in 2006 in Upper Camelot Lake, with a mean density of 1.92 (on a scale of 1 to 4). In the lake overall, none of the aquatic vegetation had a mean density of over 2.0, meaning none occurred at more than average, in 2006.

A healthy and diverse aquatic plant community plays a vital role within the lake ecosystem. Plants help improve water quality by trapping nutrients, debris and pollutants in the water body; by absorbing and/or breaking down some pollutants; by reducing shore erosion by decreasing wave action and stabilizing shorelines and lake bottoms; and by tying-up nutrients that would otherwise be available for algae blooms. Aquatic plants provide valuable habitat resources for fish and wildlife, often being the base level for the multi-level food chain in the lake ecosystem, and also produce oxygen needed by animals.

Further, a healthy and diverse aquatic plant community can better resist the invasion of species (native and non-native) that might otherwise "take over" and create a lower quality aquatic plant community. A well-established and diverse plant community of natives can help check the growth of more tolerant (and less desirable) plants that would otherwise crowd out some of the more sensitive species, thus reducing diversity.

Vegetated lake bottoms support larger and more diverse invertebrate populations that in turn support larger and more diverse fish and wildlife populations (Engel, 1985). Also, a mixed stand of aquatic macrophytes (plants) supports 3 to 8 times more invertebrates and fish than do monocultural stands (Engel, 1990). A diverse plant community creates more microhabitats for the preferences of more species.

MANAGEMENT RECOMMENDATIONS

(1) Because the plant cover in the littoral zone of Upper Camelot Lake is over the ideal (25%-85%) coverage for balanced fishery and there are some areas with more than average plant density, continued harvesting to open fishing lanes should occur in some areas. Plant removal should occur by hand in the shallower areas to be sure that entire plants are removed and to minimize the amount of disturbance to the sediment.

(2) Natural shoreline restoration and erosion control in many areas is needed, especially on some bare steep banks. If trees fall at the eroded sites due to continued erosion, large portions of the banks will fall with them.

(3) To protect water quality and preserve shorelines, a buffer area of native plants needs to be restored on those many sites that now have seawalls or have traditional lawns mowed to the water's edge. Large areas of the lake shoreline are unnatural and prone to erosion & runoff of nutrients & toxics. Unmowed native vegetation reduces runoff into the lake and filters runoff that enters the lake.

(4) The Tri-Lakes Management District and the Camelot Lake Association should continue to cooperate with the WDNR to monitor for the introduction of zebra mussel to protect the aquatic plant community in Upper Camelot Lake.

(5) To improve water quality, the following actions should be considered:

(a) The groundwater study indicated nutrients are coming from shoreline properties. To improve water quality, stormwater management of the many impervious surfaces around the lake is essential to maintain the current quality of the lake water and prevent further degradation.

(b) No lawn chemicals should be used on properties around the lake. If they must be used, they should be used no closer than 50' to the shore.

(c) No broad-scale chemical treatments of aquatic plant growth are recommended due to the undesirable side-effects of such treatments, including increased nutrients from decaying plant material and decreased dissolved oxygen and opening up more areas to the invasion of EWM.

(d) No drawdowns of water level except for DNR-approved purposes should occur. Several of the plants found in Upper Camelot Lake in 2006 are those encouraged by drawdowns.

(e) The few sites where there is undisturbed shore should be maintained and left undisturbed.

(6) The aquatic plant management plan should be reviewed annually. Mechanical harvesting plans should continue target harvesting for Eurasian Watermilfoil (EWM) and include target harvesting for Curly-Lead Pondweed to prevent further spread. Mechanical harvesting must follow the approved Lake Management Plan.

(7) The Camelot Lake Association may want to continue to apply for grants from the Wisconsin Department of Natural Resources to help defray the cost of aquatic plant management.

(8) Any fallen trees should be left in the water

(9) The Tri-Lakes Management District conducted water quality monitoring for several years, but has decreased its involvement during 2004-2006 when Adams Land & Water Conservation Department was doing more intense monitoring as part of a Lake Classification Grant. Water quality monitoring by the Lake District or through the DNR Self-Help Monitoring Program should be restarted.

(10) Upper Camelot Lake residents should identify, cooperate with and participate in watershed programs that will reduce nutrient and sediment inputs.

(11) The Tri-Lakes Management District should make sure that its lake management plan takes into account all inputs from the Upper Camelot Lake surface ground watershed, and addresses the concerns of this larger lake community.

(12) Pursue installation of sewage system around the lake to reduce nutrient input from the lakeshores. Reducing nutrient inputs by residents needs to occur before asking watershed residents to reduce theirs.

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